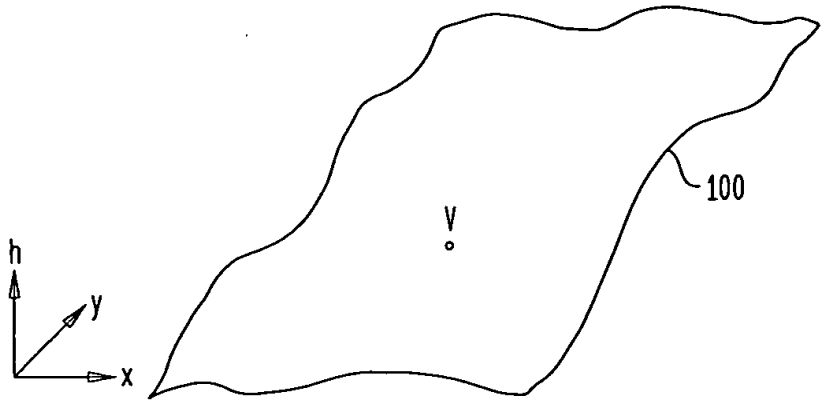
FIG. 1




EXAMPLE OF A TERRAIN DEFINED BY A HEIGHT FIELD

FIG. 2

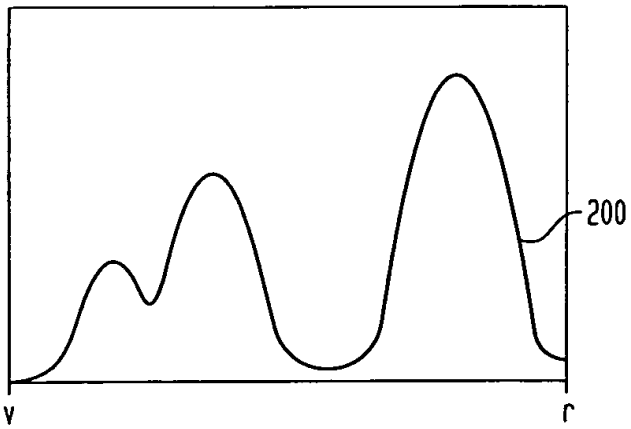


FIG. 3A

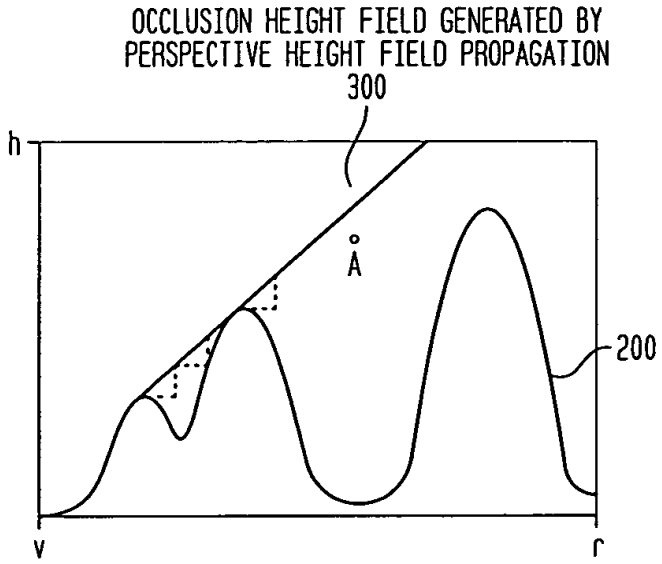

OCCLUSION HEIGHT FIELD GENERATED BY
PERSPECTIVE HEIGHT FIELD PROPAGATION
300
h
Å
200
v
r

FIG. 3B

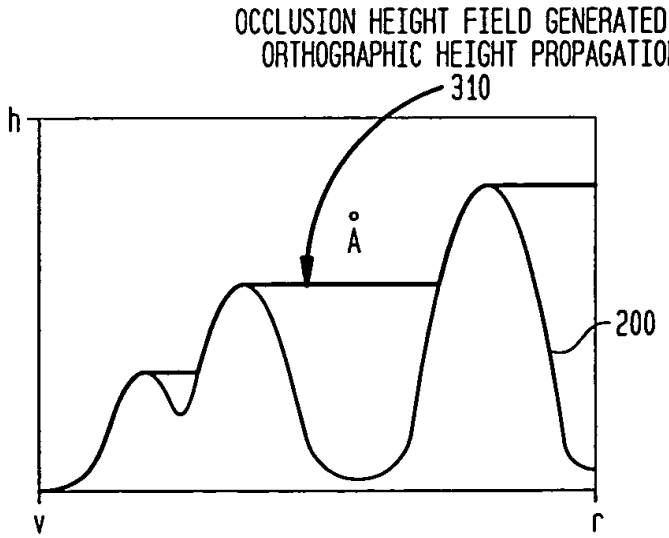

OCCLUSION HEIGHT FIELD GENERATED BY
ORTHOGRAPHIC HEIGHT PROPAGATION
310
h
Å
200
v
r

FIG. 4

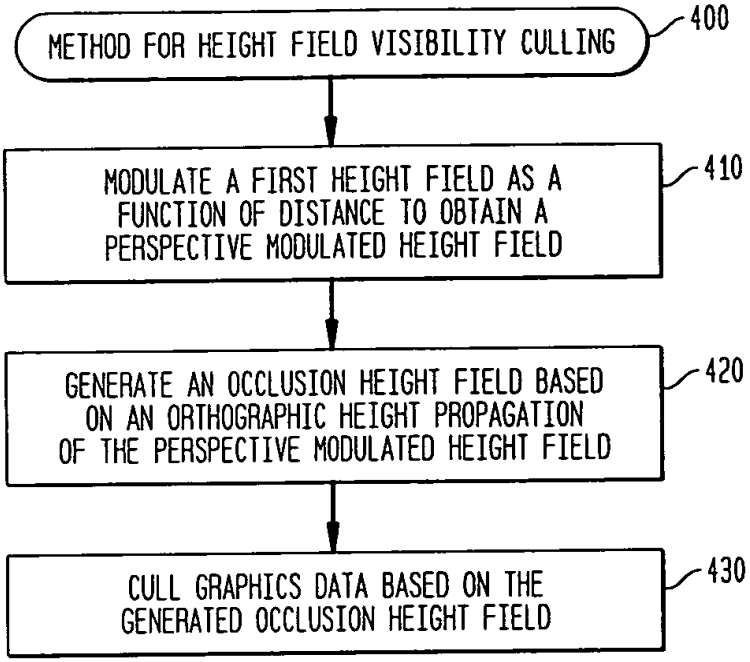

METHOD FOR HEIGHT FIELD VISIBILITY CULLING
400
MODULATE A FIRST HEIGHT FIELD AS A FUNCTION OF DISTANCE TO OBTAIN A PERSPECTIVE MODULATED HEIGHT FIELD
410
GENERATE AN OCCLUSION HEIGHT FIELD BASED ON AN ORTHOGRAPHIC HEIGHT PROPAGATION OF THE PERSPECTIVE MODULATED HEIGHT FIELD
420
CULL GRAPHICS DATA BASED ON THE GENERATED OCCLUSION HEIGHT FIELD
430

FIG. 5

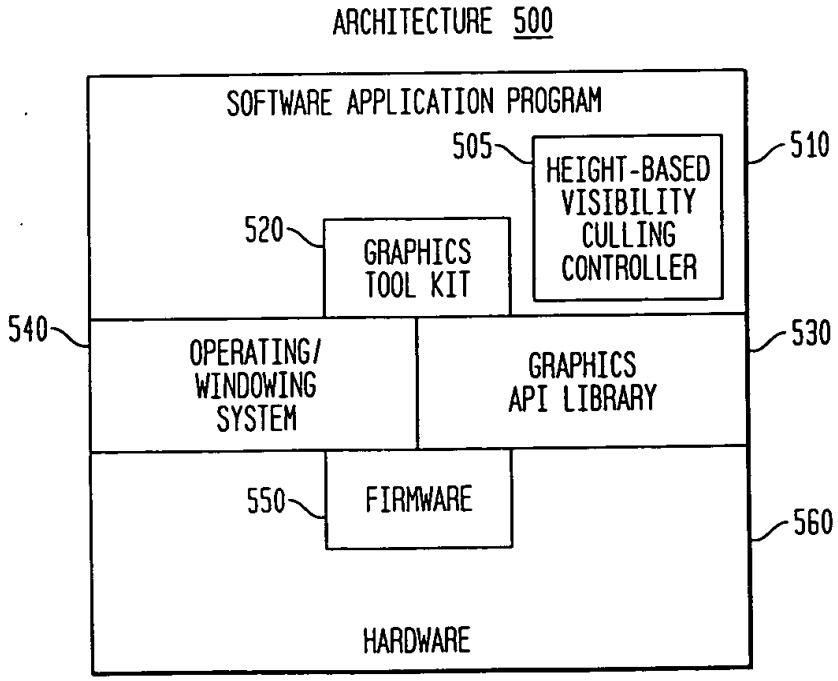

ARCHITECTURE 500
SOFTWARE APPLICATION PROGRAM
505
HEIGHT-BASED VISIBILITY CULLING CONTROLLER
510
520
GRAPHICS TOOL KIT
540
OPERATING/ WINDOWING SYSTEM
GRAPHICS API LIBRARY
530
550
FIRMWARE
560
HARDWARE

FIG. 6A

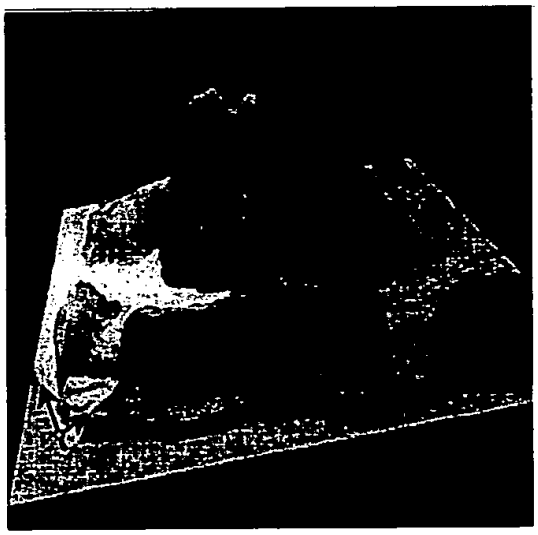


FIG. 6B

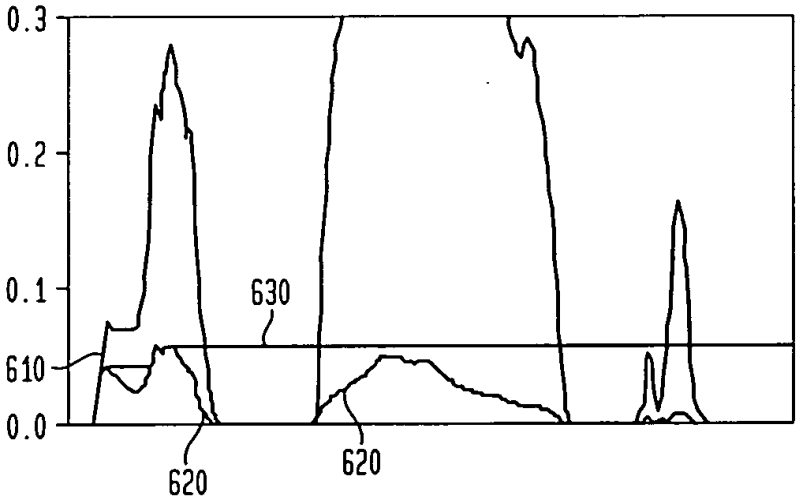


FIG. 7

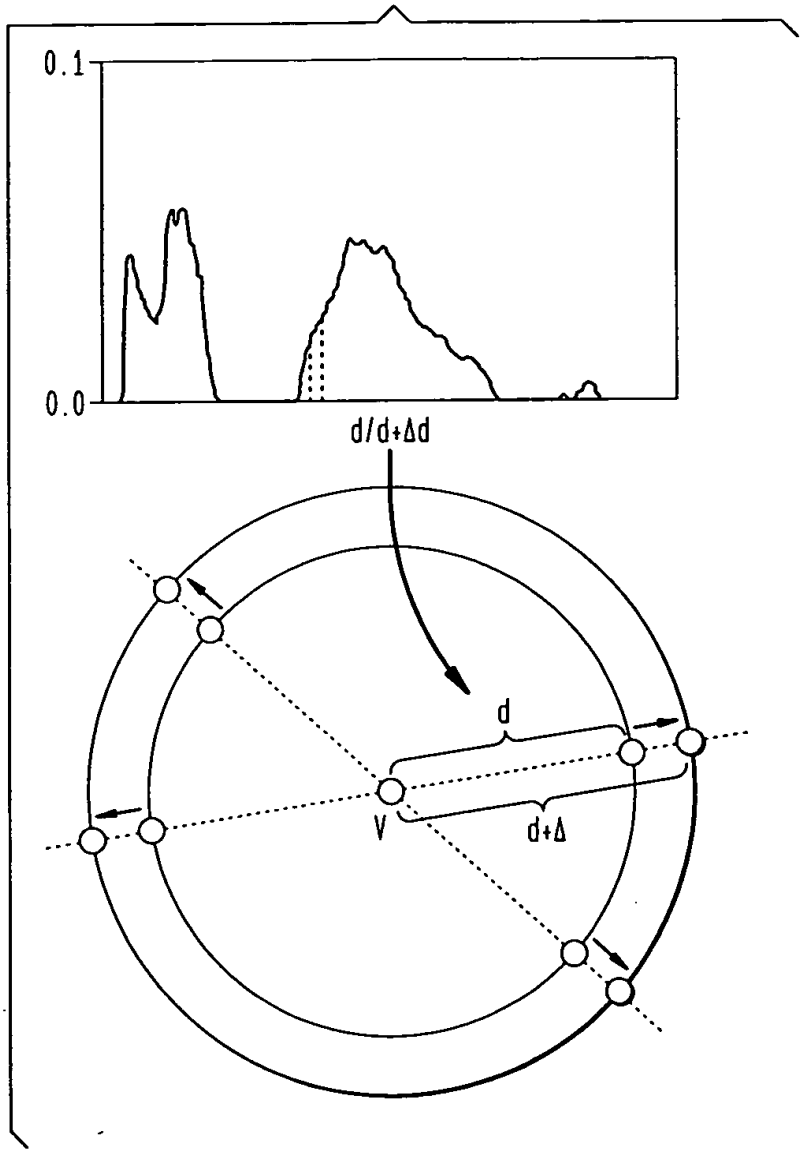


FIG. 8A

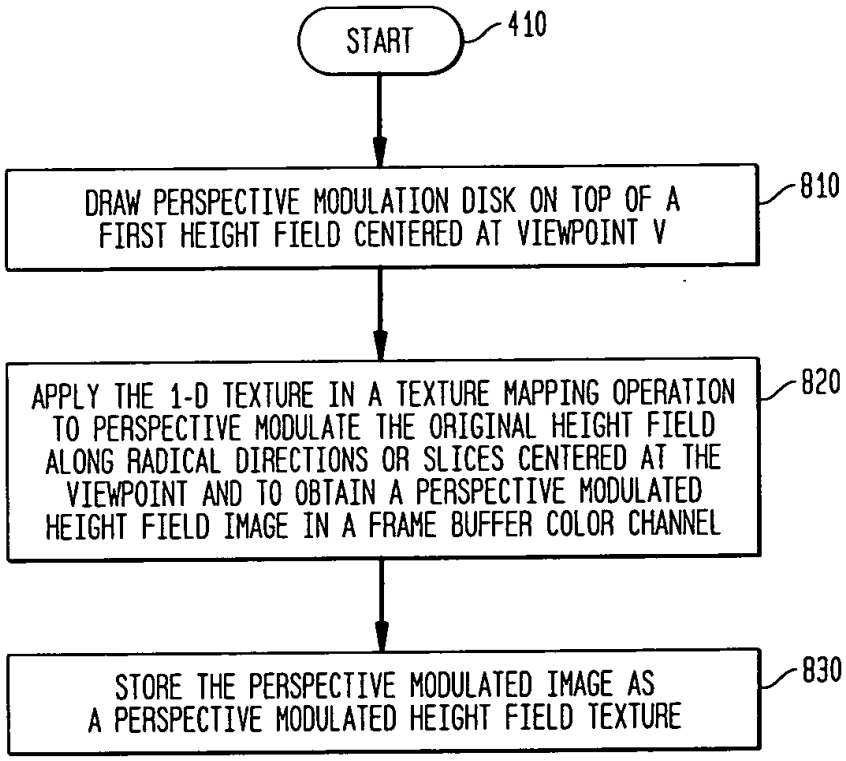

START
410
DRAW PERSPECTIVE MODULATION DISK ON TOP OF A FIRST HEIGHT FIELD CENTERED AT VIEWPOINT V
810
APPLY THE 1-D TEXTURE IN A TEXTURE MAPPING OPERATION TO PERSPECTIVE MODULATE THE ORIGINAL HEIGHT FIELD ALONG RADICAL DIRECTIONS OR SLICES CENTERED AT THE VIEWPOINT AND TO OBTAIN A PERSPECTIVE MODULATED HEIGHT FIELD IMAGE IN A FRAME BUFFER COLOR CHANNEL
820
STORE THE PERSPECTIVE MODULATED IMAGE AS A PERSPECTIVE MODULATED HEIGHT FIELD TEXTURE
830

FIG. 8B

SHIFT DISK-HEIGHT PROPAGATION FIXED AT EACH ITERATION

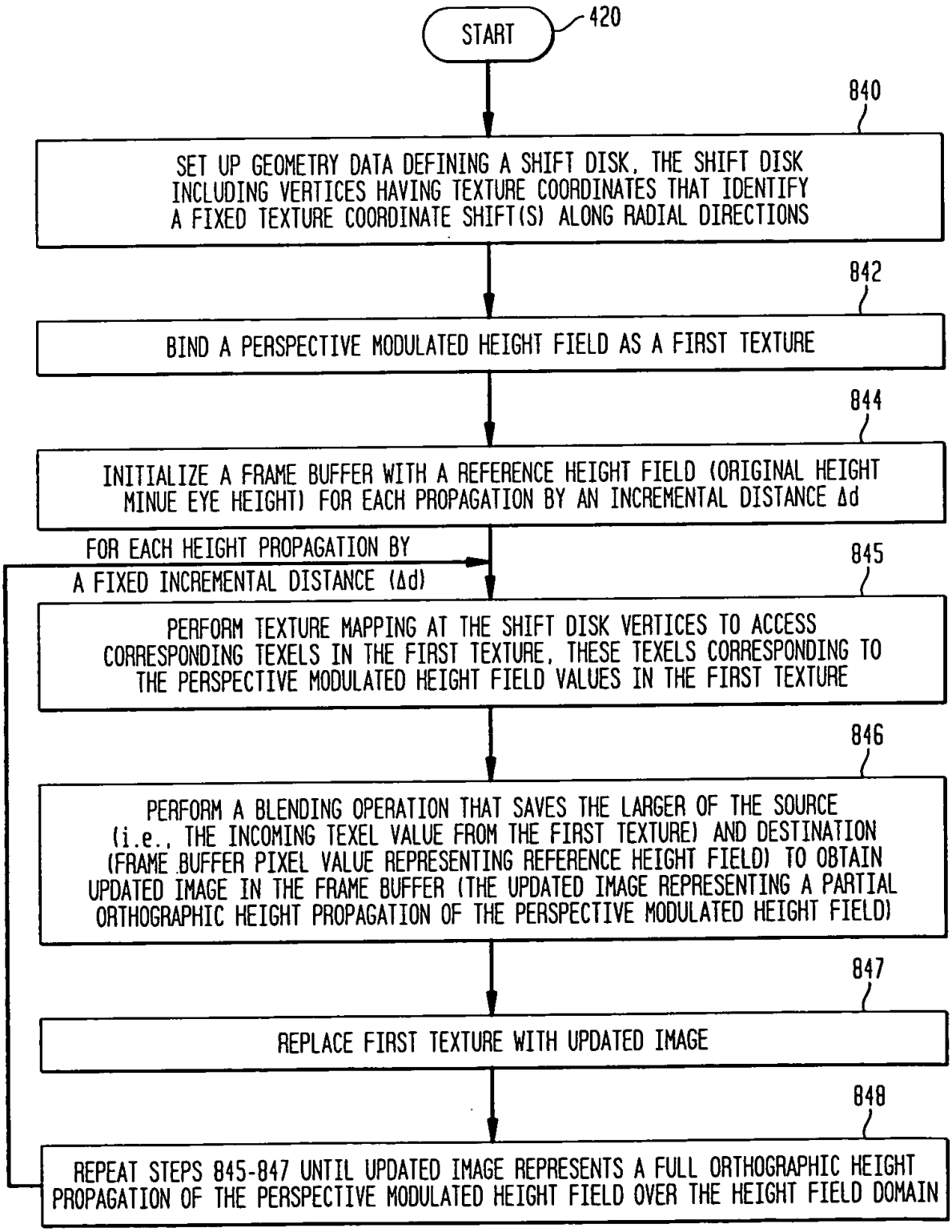


FIG. 8C

SHIFT DISK-HEIGHT PROPAGATION VARIED AT EACH ITERATION

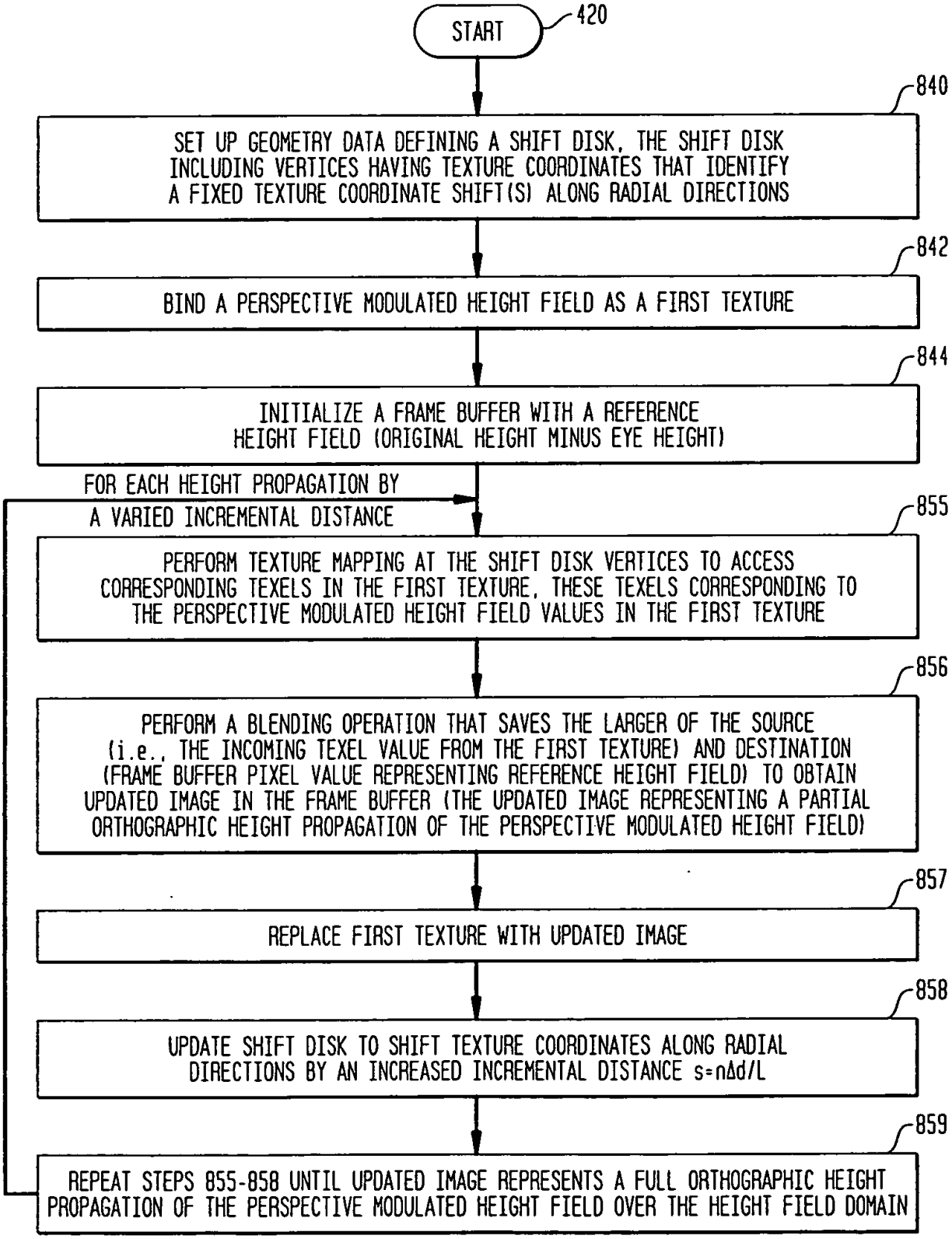


FIG. 8D

SHIFT TEXTURE-HEIGHT PROPAGATION FIXED AT EACH ITERATION

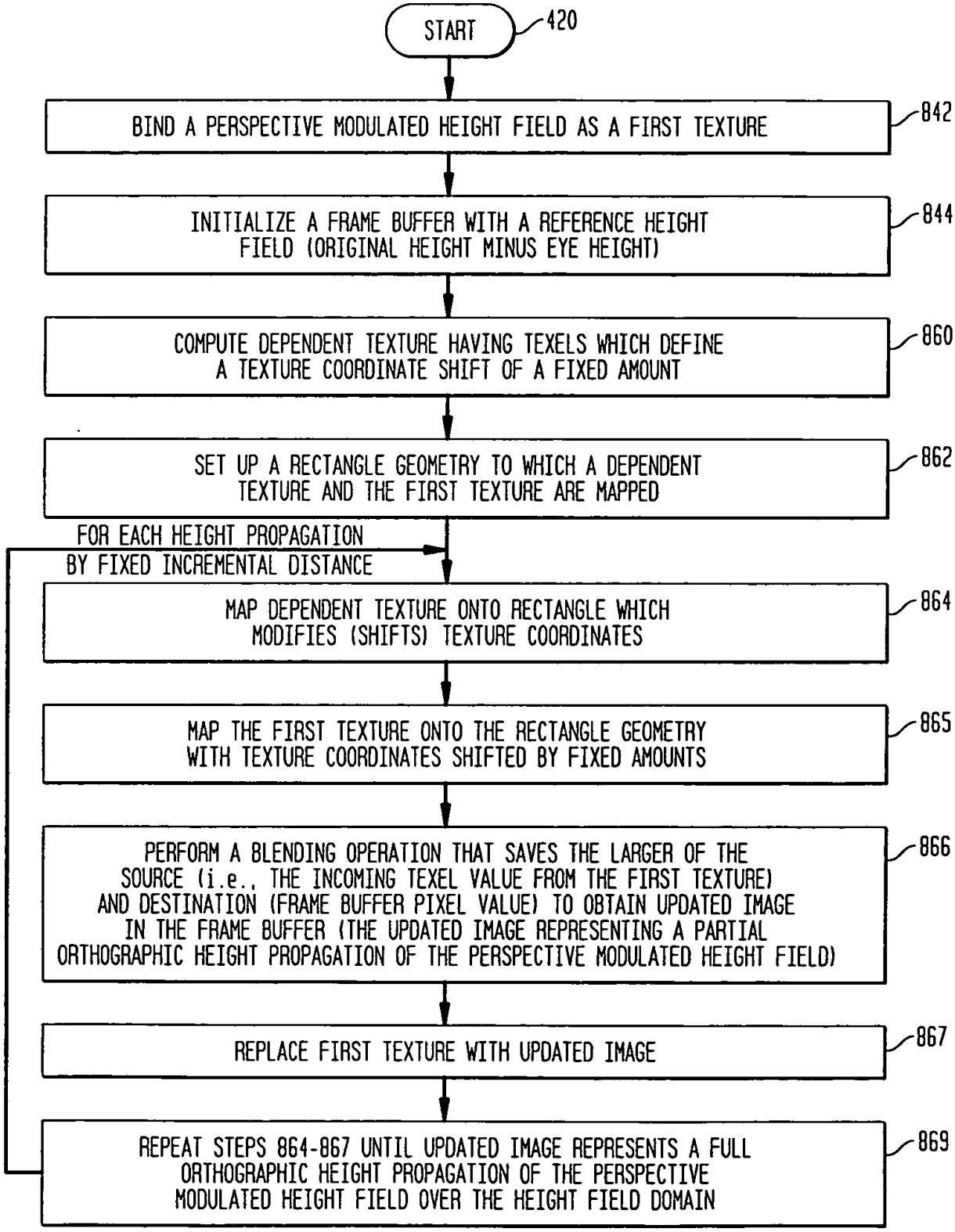


FIG. 9A

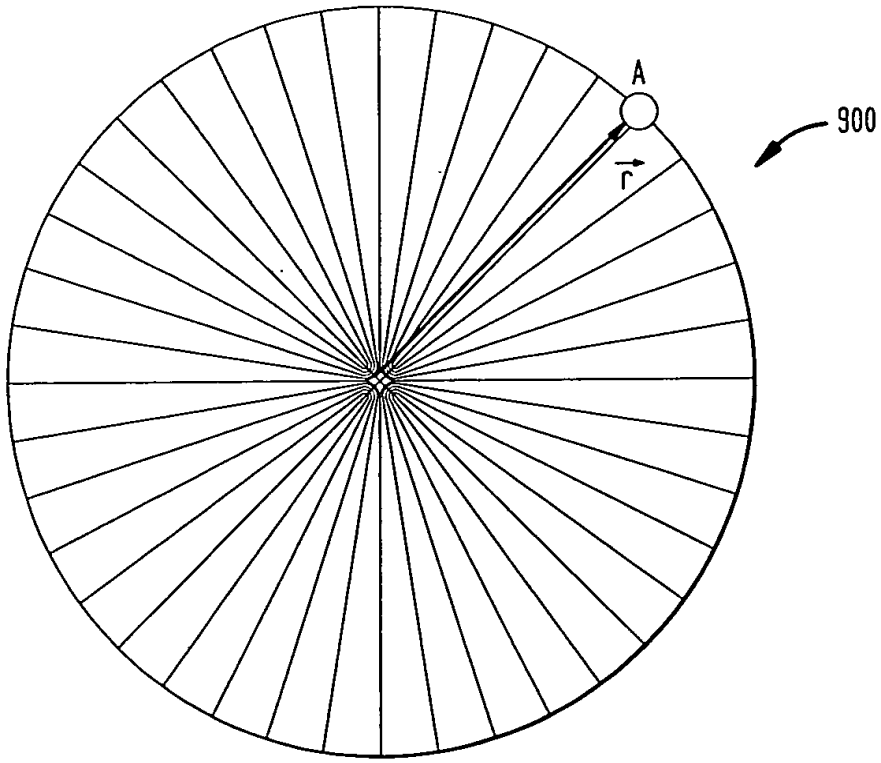
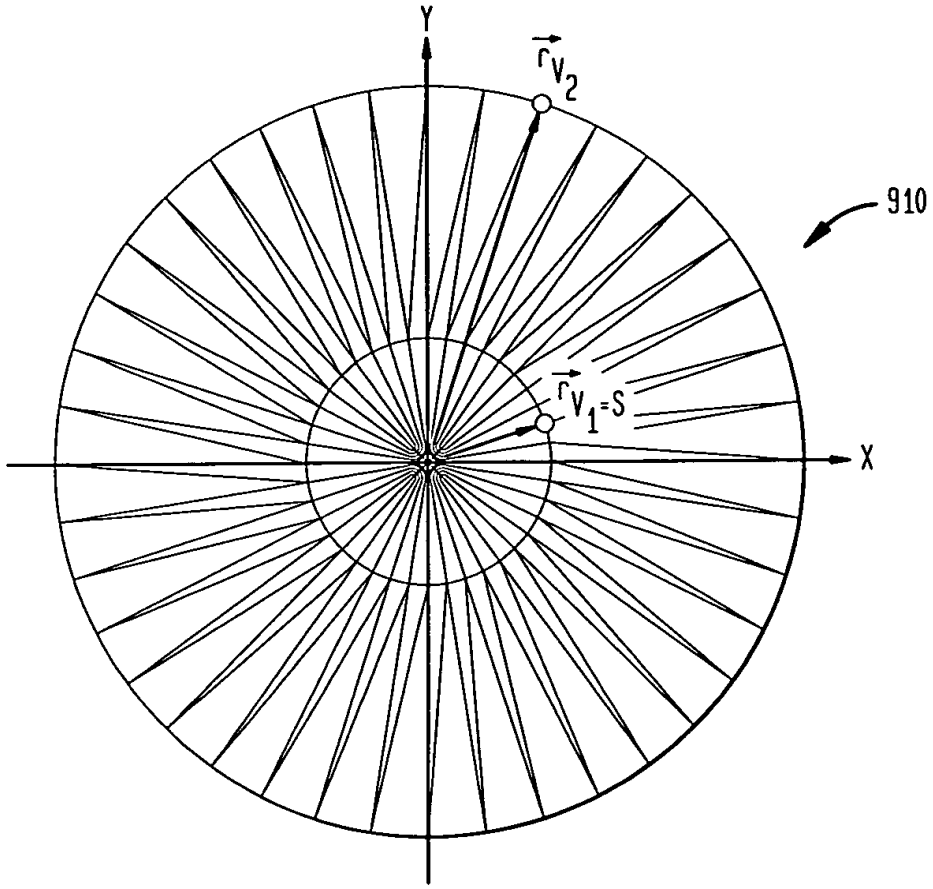


FIG. 9B




$V_1$'s POSITION $(|\vec{r}_{V_1}|\cos\theta_{V_1}/2+0.5,\ |\vec{r}_{V_1}|\sin\theta_{V_1}/2+0.5)$

$V_1$'s TEXTURE COORDINATES: (0.5, 0.5) (SAME AS THE DISK CENTER)

$V_2$'s POSITION $(|\vec{r}_{V_2}|\cos\theta_{V_2}/2+0.5,\ |\vec{r}_{V_2}|\sin\theta_{V_2}/2+0.5)$

$V_2$'s TEXTURE COORDINATES: $(|\vec{r}_{V_2}|\cos\theta_{V_2}/2+0.5,\ |\vec{r}_{V_2}|\sin\theta_{V_2}/2+0.5)$

THE SHIFT DISK. $V_1$ REPRESENTS ANY VERTEX ON THE INNER RING, AND $V_2$ THAT OF THE OUTER. s IS THE AMOUNT OF SHIFT. RADIUS OF THE INNER RING IS s. $\theta$ IS THE ANGLE WITH THE X AXIS. A TRANSLATION TO THE EYE POSITION IS ADDED TO BOTH POSITIONS AND TEXTURE COORDINATES USING THE MODEL-VIEW AND THE TEXTURE MATRIX, RESPECTIVELY, WHEN THE DISK IS DRAWN.

FIG. 10

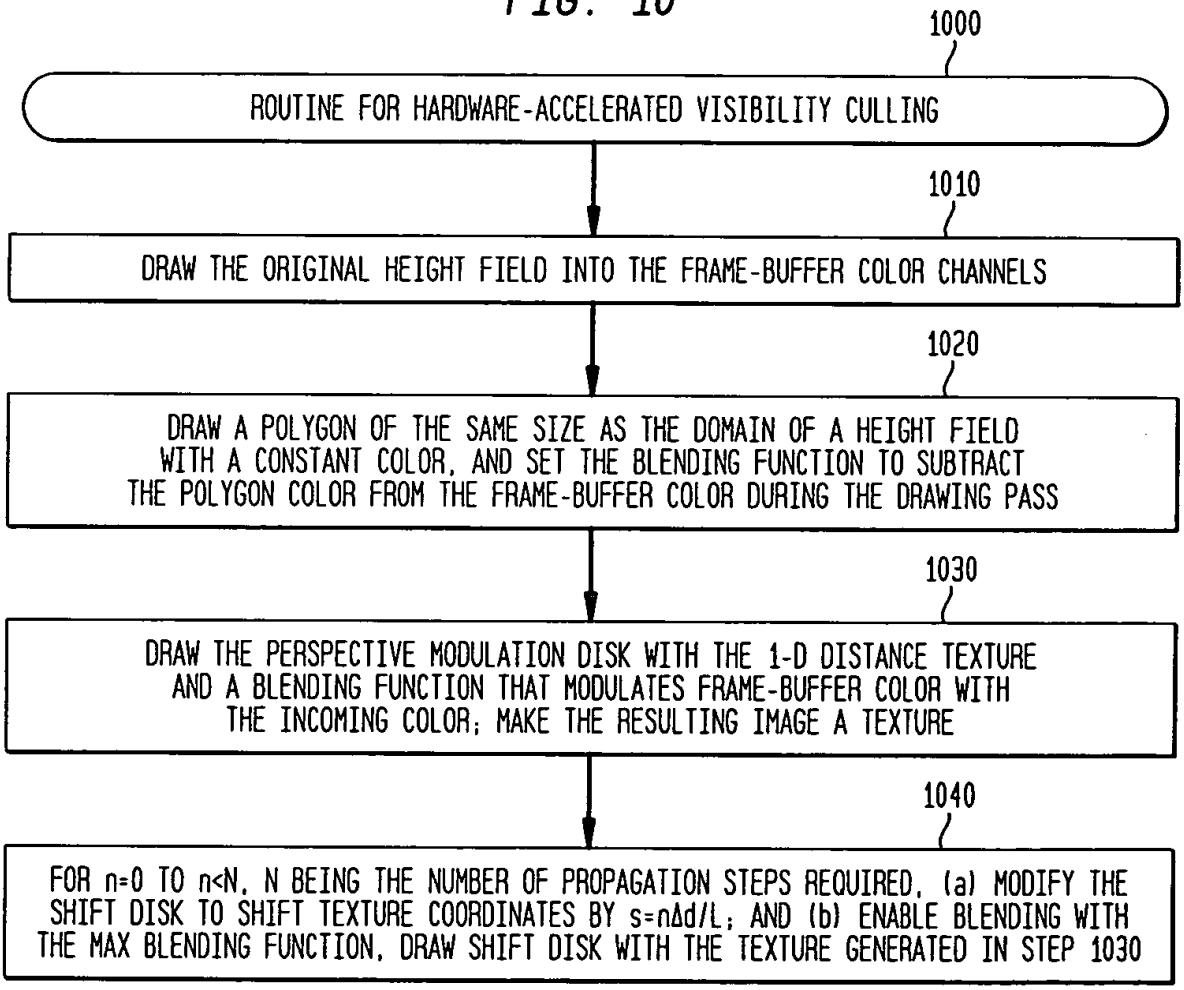

1000
ROUTINE FOR HARDWARE-ACCELERATED VISIBILITY CULLING
1010
DRAW THE ORIGINAL HEIGHT FIELD INTO THE FRAME-BUFFER COLOR CHANNELS
1020
DRAW A POLYGON OF THE SAME SIZE AS THE DOMAIN OF A HEIGHT FIELD WITH A CONSTANT COLOR, AND SET THE BLENDING FUNCTION TO SUBTRACT THE POLYGON COLOR FROM THE FRAME-BUFFER COLOR DURING THE DRAWING PASS
1030
DRAW THE PERSPECTIVE MODULATION DISK WITH THE 1-D DISTANCE TEXTURE AND A BLENDING FUNCTION THAT MODULATES FRAME-BUFFER COLOR WITH THE INCOMING COLOR; MAKE THE RESULTING IMAGE A TEXTURE
1040
FOR n=0 TO n<N, N BEING THE NUMBER OF PROPAGATION STEPS REQUIRED, (a) MODIFY THE SHIFT DISK TO SHIFT TEXTURE COORDINATES BY s=nΔd/L; AND (b) ENABLE BLENDING WITH THE MAX BLENDING FUNCTION, DRAW SHIFT DISK WITH THE TEXTURE GENERATED IN STEP 1030

FIG. 11

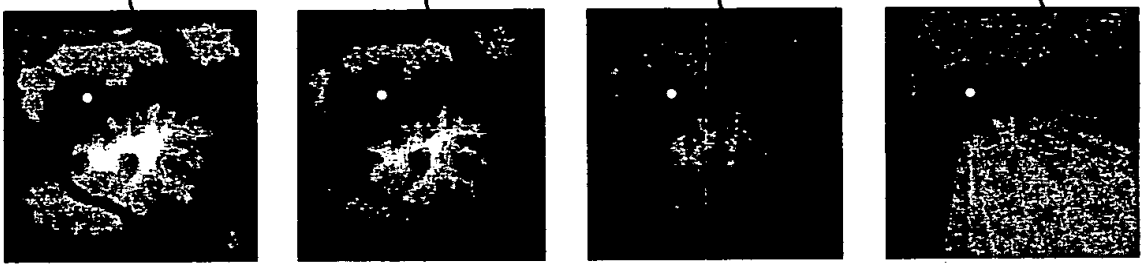
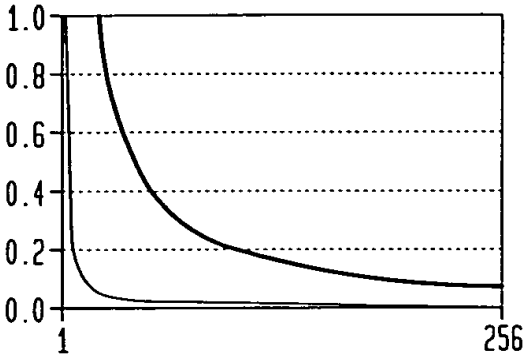
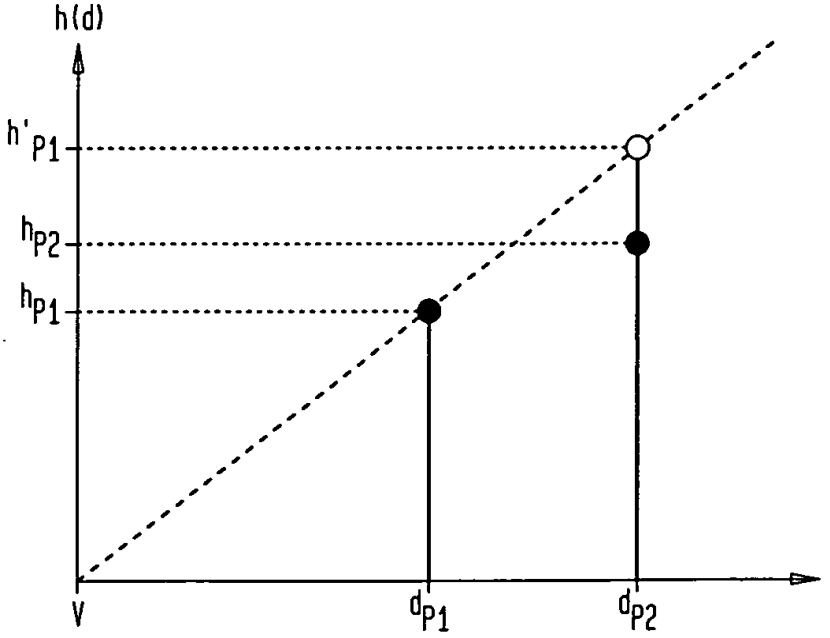

1110
1120
1130
1140
ORIGINAL
ORIGINAL - EYE HEIGHT
PERSPECTIVE - MODULATED (X4 FOR ILLUSTRATION PURPOSES)
AFTER N STEPS PROPAGATION (X4 FOR ILLUSTRATION PURPOSES)

FIG. 12




THE 1/d FUNCTION (THE THINNER LINE) AND THE SAME FUNCTION MULTIPLED BY A FACTOR OF 20 (i.e., $f_{\vec{H}}$ 20). USING THE LATTER FOR PERSPECTIVE MODULATION RESULTS IN MORE USEABLE RANGE IN THE MODULATED HEIGHT FIELD AND THUS THE OCCLUSION HEIGHT FIELD DERIVED FROM IT.

FIG. 13




ORTHOGRAPHIC HEIGHT PROPOGATION ON A HEIGHT FIELD, AFTER PERSPECTIVE MODULATION, IS EQUIVALENT TO PERSPECTIVE HEIGHT PROPAGATION ON THE ORIGINAL HEIGHT FIELD

FIG. 14

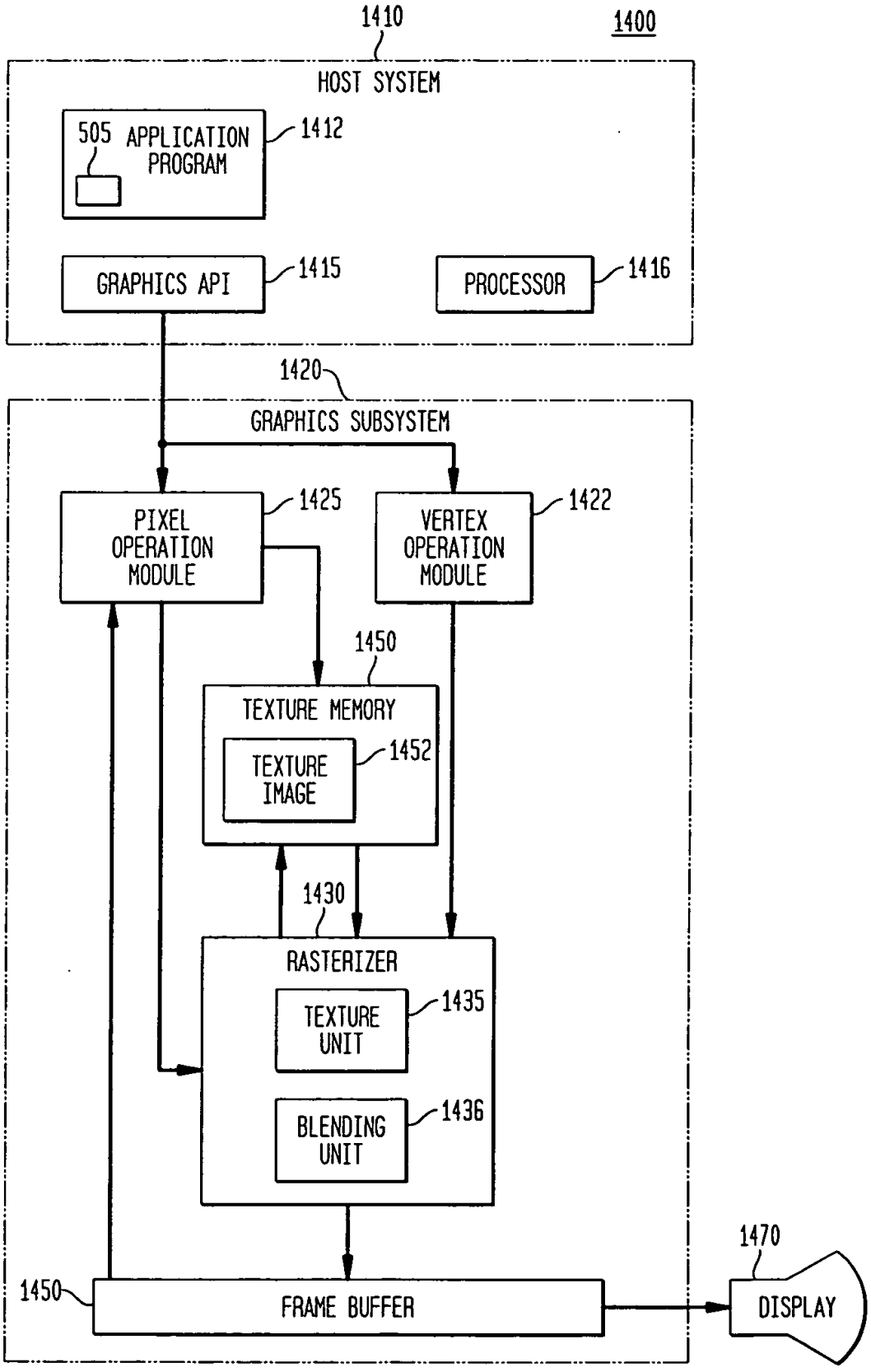
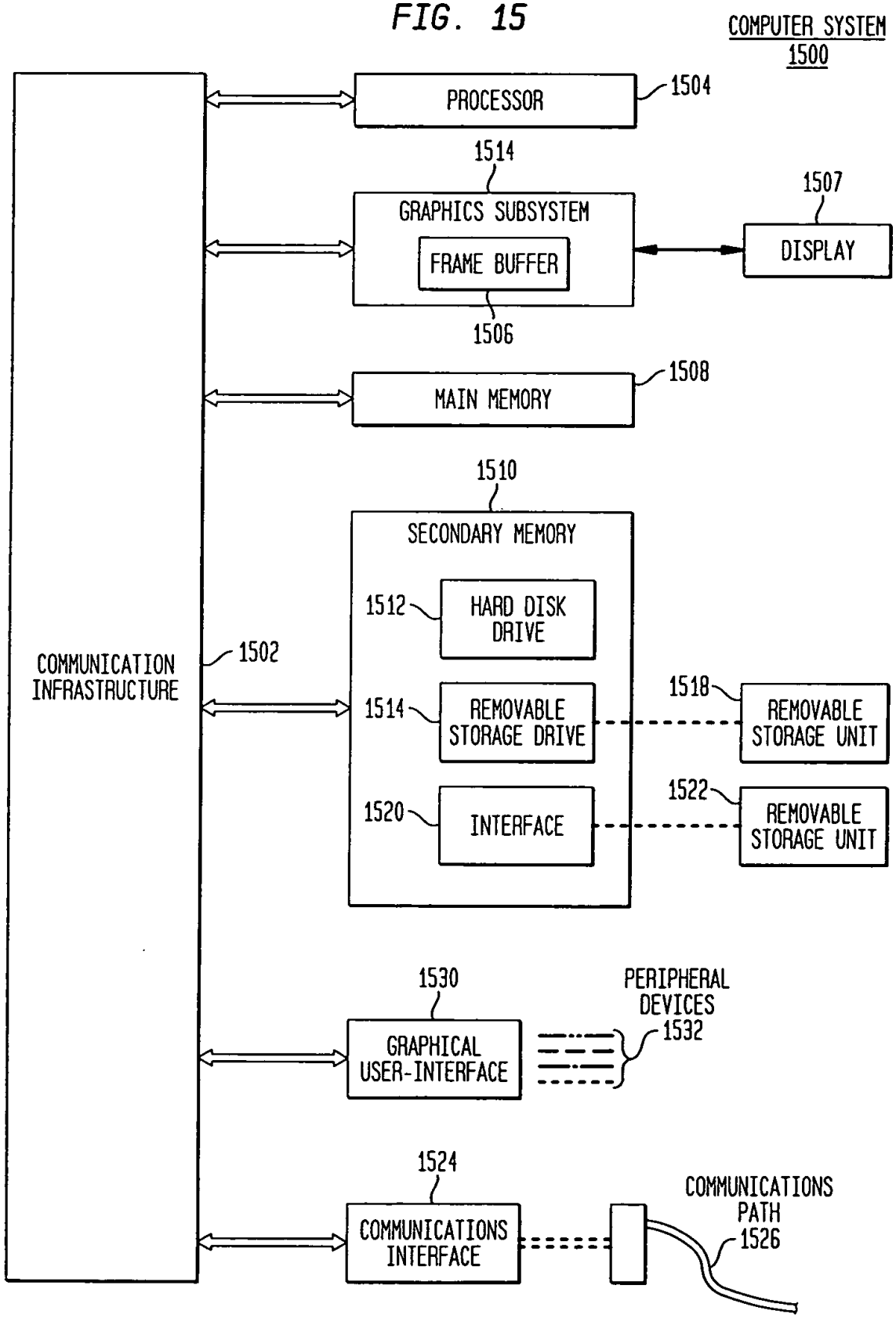

1410
1400
HOST SYSTEM
505 APPLICATION PROGRAM
1412
GRAPHICS API
1415
PROCESSOR
1416
1420
GRAPHICS SUBSYSTEM
PIXEL OPERATION MODULE
1425
VERTEX OPERATION MODULE
1422
1450
TEXTURE MEMORY
TEXTURE IMAGE
1452
1430
RASTERIZER
TEXTURE UNIT
1435
BLENDING UNIT
1436
1450
FRAME BUFFER
1470
DISPLAY

FIG. 15


COMPUTER SYSTEM
1500
PROCESSOR
1504
1514
GRAPHICS SUBSYSTEM
FRAME BUFFER
1506
1507
DISPLAY
MAIN MEMORY
1508
1510
SECONDARY MEMORY
1512
HARD DISK DRIVE
1514
REMOVABLE STORAGE DRIVE
1518
REMOVABLE STORAGE UNIT
1520
INTERFACE
1522
REMOVABLE STORAGE UNIT
COMMUNICATION INFRASTRUCTURE
1502
1530
GRAPHICAL USER-INTERFACE
PERIPHERAL DEVICES
1532
1524
COMMUNICATIONS INTERFACE
COMMUNICATIONS PATH
1526